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A GIS-based Inductive Study of Wilderness Values

BY GREGORY BROWN AND LILIAN ALESSA

Abstract: This study presents the results of spatial analysis of wilderness values in Alaska. Using data from two regional planning studies, perceived landscape values from inside and outside wilderness areas were compared to determine if proportionate value differences exist between wilderness and nonwilderness areas. Multiple regression analysis was used to confirm the results and determine the relative strength of general landscape values as predictors of wilderness value. Results indicate that wilderness areas reflect values associated with indirect, intangible, or deferred human uses of the landscape—life-sustaining, intrinsic, and future values—whereas landscape values outside wilderness areas reflect more direct, tangible, and immediate uses of the landscape—economic, recreation, and subsistence values.

Co-article author Gregory Brown

Introduction

One approach to measuring wilderness values in the United States has been to survey the general public as part of the National Survey on Recreation and the Environment (NSRE) (Cordell et al. 2003; Cordell et al. 1998). The 13-item Wilderness Values Scale (WVS) used in the survey measures both use and nonuse values (e.g., preservation) for wilderness in the National Wilderness Preservation System (NWPS). This national survey approach presents the NWPS as a generalized, abstract system for the general public to evaluate. The most recent results suggest that ecological and existence values are central to Americans' viewpoint on wilderness (Cordell et al. 2003) and that direct use values are generally less important than ecological, environmental quality, and off-site values (Cordell et al. 1998).

An alternative, inductive approach to examining wilderness values, and the method presented herein, is to present landscapes as tabulae rasae to the general public at both the community and regional levels, so individuals can spatially identify landscape values, including those associated with wilderness areas. Presumably, if wilderness areas possess a range of landscape values that are proportionately different from landscapes outside of wilderness areas, these value differences will emerge as a result of inductive analysis of the spatial location of values. The emergent values of wilderness areas can then be compared to those reported from national survey results.

As part of the Chugach National Forest (CNF) planning process, Brown and Reed (2000) developed a landscape values typology to provide residents of local communities with the opportunity to rank and spatially identify landscape values. The values typology, although somewhat different from the WVS, shares 9 out of 13 values with the WVS used in the NSRE (see Table 1). One of the important issues in the development of the initial values typology was whether "wilderness" value constituted a separate landscape value, or whether wilderness value was an emergent characteristic resulting from a combination of other landscape values. In the end, wilderness value was not included as a separate value in the CNF value typology.

In 2002 the authors measured landscape values for a different planning area in Alaska, the Kenai Peninsula. In this study we included wilderness value as a separately defined value in the landscape values typology. By including wilderness value as a separate landscape value, we set the stage for this study to determine which nonwilderness landscape values are predictive of wilderness values and which landscape values tend to associate with de facto or actual wilderness units in the NWPS.

Thus, the purpose of this empirical study was threefold: (1) to examine the mix of landscape values that the public identifies *inside* actual or de facto wilderness areas to compare with values identified *outside* wilderness areas in order to determine what, if any, proportional value differences exist; (2) to determine which landscape values best predict perceived wilderness values from the Kenai Peninsula study using multiple regression, using the full range of landscape values; and (3) to compare our study results with the 2000 NSRE survey results on wilderness values (i.e., landscape values that appear disproportionately inside wilderness areas could be significant predictors of wilderness values in a regression model).

Methods

Survey Methods

The CNF planning survey was implemented in March 1998 using a modified Dillman (1978) total design survey methodology. A survey booklet, consisting of five sections, along with a color CNF map was sent to 2,766 randomly selected households in 12 communities (Anchorage, Cooper Landing, Cordova, Girdwood, Hope/Sunrise, Kenai, Moose Pass, Seward, Soldotna, Sterling, Valdez, and Whittier) in close proximity to the forest. In addition, a smaller, statewide random sample of households was selected for inclusion in the study.

Table 1. Value Typologies from Three Surveys Used in This Study.

Chugach National Forest study[1] (1998)	Kenai Peninsula study[2] (2002)	NSRE (2000) Wilderness Values Scale[3]
Aesthetic	Aesthetic	Scenic beauty
Economic	Economic	Tourism income
Recreation	Recreation	Recreation opportunities
Learning	Learning	Scientific study
Spiritual	Spiritual	Spiritual inspiration
Intrinsic	Intrinsic	Knowing it exists
Future	Future	Option for future generations
		Option for personal use
Life sustaining	Life sustaining	Protecting water quality
		Protecting air quality
Biological diversity	Biological diversity	Protecting wildlife habitat
		Preserving unique wild plants and animals
		Protecting rare and endangered species
Therapeutic	Therapeutic	N/A[4]
Cultural	Cultural	N/A
Subsistence	Subsistence	N/A
Historic	Historic	N/A
N/A	Wilderness	N/A

[1]See Brown and Reed (2000).
[2]See Brown et al. (2004).
[3]See Cordell et al. (2003).
[4]N/A—not available; no comparable value item included.

Of relevance to this study was the part of the survey that asked participants to place mnemonically coded sticker dots (1/4 inch) representing 13 landscape values on the CNF map provided with the survey. Upon return, the landscape value locations were digitized onto a scanned and georectified CNF map image using ArcView GIS software. The map scale was approximately 1 inch equal to 8 miles, with the 1/4-inch diameter dot covering 2 miles across. A total of 768 maps (28% response rate) were returned, with 16,839 point locations digitized for analysis.

The Kenai Peninsula planning survey was implemented in spring 2002. A survey booklet, consisting of six sections, along with a grayscale map of the study area were sent to 2,582 randomly selected households in 12 Kenai proximate communities (Anchorage, Anchor Point, Clam Gulch, Homer, Hope, Kasilof, Kenai, Nanwalek/Port Graham, Nikiski, Ninilchik, Seldovia, and Seward).

In addition to the same 13 landscape values included in the CNF study, the Kenai study also included three "wilderness" value sticker dots per survey. Similar to the CNF study, the dot locations were digitized onto a scanned and georectified map image. The map scale was approximately 1 inch equal to 7 miles with the 1/4-inch diameter dot covering 1.8 miles across.

One important methodological consideration is that the wilderness study area in the Chugach National Forest and the designated wilderness area in the Kenai National Wildlife Refuge were *not* identified on the maps enclosed with the surveys. We make the assumption that the survey participants, even if knowledgeable about the existence of these wilderness designations, would likely not have known actual wilderness boundaries. Thus, survey participants were "blind" to the research question—perceptions of perceived wilderness value were based on perceived landscape attributes, not wilderness boundary considerations.

Landscape Value Spatial Analysis

To determine whether the proportion of landscape values differs based on value location inside or outside a wilderness area, landscape value point locations were divided into two sets—those falling inside and those falling outside the wilderness boundary. In the CNF study, the wilderness study area defined by the Alaska National Interests Lands Conservation Act (1980) and identified as "recommended wilderness" in the 1984 Chugach Land and Resource Management Plan, was used as the wilderness

Table 2. Similarities and Differences in the Distribution of Landscape Values Inside/Outside Wilderness Areas from Two Alaska Studies.

Chugach NF study (1998)	Kenai Peninsula study (2002)
Inside[1]	
Life sustaining (16.4% vs. 9.6%)	Life sustaining (10.1% vs. 6.1%)
Intrinsic (11.3% vs. 5.4%)	Intrinsic (11.9% vs. 6.1%)
Future (13.7% vs. 9.0%)	Future (9.8% vs. 6.1%)
Spiritual (6.2% vs. 4.9%)	
	Wilderness (21.7% vs. 8.3%)
Outside	
Economic (6.5% vs. 4.2%)	Economic (8.3% vs. 2.3%)
Historic (5.5% vs. 3.2%)	Historic (6.9% vs. 3.9%)
Subsistence (7.3 vs. 4.0%)	Subsistence (7.6% vs. 4.7%)
Aesthetic (12.0% vs. 9.4%)	
Recreation (13.5% vs. 7.1%)	
No difference[2]	
Biological diversity	Biological diversity
Learning	Learning
Therapeutic	Therapeutic
Cultural	Cultural
	Recreation
	Aesthetic
	Spiritual

[1]Inside and outside classifications represent statistically significant differences in value proportions (chi-square, $p < .05$).

[2]"No difference" indicates landscape value proportions located inside vs. outside wilderness areas are not statistically significant (chi-square, $p > .05$), but the relative abundance of values located inside/outside is noted.

boundary. In the Kenai Peninsula study, the congressionally designated wilderness area within the Kenai National Wildlife Refuge was used as the wilderness boundary. Using a spatial "clip" operation on wilderness boundaries, landscape value locations were classified as either being inside or outside the wilderness boundaries.

After assigning an inside or outside wilderness attribute to each landscape value, cross-tabulations with chi-square analysis were completed in SPSS software for each landscape value to determine whether the relative proportion of values located inside the wilderness area deviated from what would be expected based on the overall proportion of landscape value locations in the study area. Large deviations between the number of observed and expected landscape values inside the wilderness boundary result in higher chi-square values and a lower probability that the distribution of values is due to chance alone.

Multiple Regression Analysis

To conduct multiple regression analysis on wilderness value in the Kenai Peninsula study, some preliminary data preparation was required. A study area polygon was established to capture most respondent-identified value locations, but to exclude obvious point outliers. The selected study area polygon consisted of the Kenai Peninsula coastline buffered to approximately 5,000 meters (3.1 miles) offshore. Each of the 14 landscape value point distributions were then converted to raster data (grids) in ArcView Spatial Analyst by calculating the density of point locations using a consistent density criteria (1,500-meter [0.9-mile] grid cell, 5,000 meter [3.1-mile] search radius). Each grid was then clipped to the study area polygon, resulting in 11,779 grid cells for analysis.

Each grid cell represents three values (x, y, z), with x and y denoting unique spatial coordinates (latitude and longitude) and *z* denoting the calculated landscape value density. Thus, a given grid cell would have 14 separate landscape value density attributes (including wilderness value) associated with it. The 14 value grids were exported as (x, y, z) data and imported into SPSS software for multiple regression analysis.

The purpose of the regression analysis was to determine the relative strength of the predictor variables, not to validate a wilderness values predictive model per se. With wilderness value density as the dependent variable, multiple regression was performed with the 13 other landscape value densities as independent variables. Lacking sound theoretical reasons for including or excluding predictors in the regression model, the "stepwise" method of regression was chosen to select predictors based on a purely mathematical criterion. The primary methodological concern is with the expected collinearity, which can influence the importance of predictor variables shown by the model's standardized beta coefficients. In the absence of serious collinearity problems, larger absolute values of standardized beta coefficients indicate stronger predictors of the dependent variable.

Results

A total of 880 full or partially completed surveys were returned for an aggregate response rate of 32%. A total of 561 full or partially completed surveys were returned for an aggregate response rate of 23%. A total of 497 maps (20.4% response rate) were returned, with

20,415 point locations digitized for analysis.

Landscape Values in Wilderness Areas

The relative proportion of landscape values located inside and outside wilderness areas in the two studies appears in Table 2. The similarity in landscapes values appearing inside and outside wilderness areas in the two studies is striking. In the CNF study, proportionately more life-sustaining, intrinsic, future, and spiritual values were located inside the wilderness study area (chi-square, $p < .05$), whereas proportionally more economic, aesthetic, recreation, historic, and subsistence values were located outside the wilderness study area (chi-square, $p < .05$). There was no difference in the proportion of biological diversity, learning, therapeutic, and cultural values located inside and outside the wilderness study area.

In the Kenai Peninsula study, proportionately more life-sustaining, intrinsic, and future values were located inside the wilderness study area (chi-square, $p < .05$), whereas proportionally more economic, historic, and subsistence values were located outside the wilderness area (chi-square, $p < .05$). There was no difference in the proportion of biological diversity, learning, therapeutic, cultural, recreation, aesthetic, and spiritual values located inside and outside the wilderness area. Even where the differences in proportions were not statistically significant, the relative abundance of landscape values located inside and outside the wilderness boundary was similar in the two studies.

One important result is that the proportion of wilderness values located in the Kenai National Wildlife Refuge wilderness area was significantly higher than the proportion of wilderness values located outside the wilderness area (21.7% vs. 8.3%).

Table 3. Stepwise Regression Results for Wilderness Value Density (Dependent Variable) as a Function of Landscape Value Densities (Independent Variables).

——— Model fit ———

Multiple R	.646
R^2	.417
Standard error	.02774

——— Model results ———

	df	SS	MS	F	Sig.
Regression	6.485	12	.540	702.32	.000
Residual	9.053	11766	.001		

——— Final variables in the equation ———

	Unstandardized		Standardized			Collinearity Statistics	
Variable	**B**	**SE B**	**Beta**	**t**	**Sig.**	**Tolerance**	**VIF**
Economic	-.202	.006	-.505	-33.016	.000	.212	4.718
Intrinsic	.395	.014	.342	27.250	.000	.314	3.182
Aesthetic	.118	.007	.332	16.344	.000	.120	8.321
Future	.316	.015	.283	20.624	.000	.264	3.790
Recreation	-.080	.008	-.194	-10.350	.000	.141	7.113
Life sustaining	.196	.013	.193	14.644	.000	.286	3.501
Subsistence	-.054	.007	-.109	-8.199	.000	.282	3.544
Historic	.047	.009	.081	5.194	.000	.203	4.924
Biological	.030	.009	.055	3.149	.002	.164	6.087
Spiritual	-.026	.010	-.031	-2.589	.010	.355	2.820
Constant	.017	.000		51.30	.000		

Prediction of Wilderness Value

The 13 values in the typology were used to predict the location of wilderness values in the Kenai Peninsula study. One value, cultural, failed to enter the regression model because the predefined tolerance level (.000) to avoid significant multicollinearity was not satisfied. Of the 12 remaining predictor variables, 10 were found to be statistically significant predictors of wilderness value through stepwise regression (see Table 3). All six variables that were statistically significant in the inside/outside analysis were also statistically significant predictors in the regression analysis model. The overall fit of the regression model was statistically significant ($R = .65$).

Whereas the inside/outside analysis measures whether landscape value associations are likely to exist, the beta coefficients from regression analysis add a second information dimension—the strength and direction of relationship between the predictor landscape values and wilderness value. The most significant predictor variables, based on the standardized beta coefficients, were economic value (negatively associated with wilderness), intrinsic value (positively associated with wilderness), aesthetic value (positively associated), future value (positively associated), recreation value (negatively associated), life sustaining (positively associated), and subsistence value (negatively associated). Economic value ($ß = -.505$), intrinsic value ($ß = .342$), and aesthetic value ($ß = .332$) were particularly strong predictors of wilderness value.

The two variables dropped from the regression equation were therapeutic value and scientific (knowledge) value. These results are consistent with the 2000 NSRE results that showed "science" and "recreation" values to be in the lower echelon of wilderness values.

Collinearity diagnostics on the regression suggest probable collinearity in the independent variables, but this was not unexpected, as landscape values are not presumed to be spatially independent. The collinearity diagnostics show weak independent variable dependencies, with Variance Inflation Factors (VIF) values ranging from 2.8 to 8.3, below the threshold of 10 for obvious concern (Myers 1990).

Discussion

If national surveys of Americans conclude that nonuse values of wilderness *as a system* are increasingly important, then one ought to find evidence *in specific wilderness areas* at the state or regional level. Our data from wilderness areas in Alaska indicate disproportionately more values associated with indirect, intangible, or deferred human uses of the landscape—life-sustaining, intrinsic, and future values. Values outside wilderness areas reflect disproportionately more direct, tangible, and immediate uses of the landscape—economic, recreation, and subsistence values. These results were confirmed through multiple regression analysis showing intrinsic, aesthetic, future, and life-sustaining values to be relatively strong positive predictors of wilderness value, whereas economic and recreation values were relatively strong antipodal predictors of wilderness value. These regional results from Alaska are wholly consistent with the 2000 NSRE results and reflect the historical increase in nonuse values of wilderness, particularly life-support values.

Aside from the value of triangulating national survey results, our results suggest the potential for using perceived landscape values to complement traditional GIS-based wilderness quality assessments. The traditional approach to assessing wilderness quality—developing indicators of naturalness and remoteness—does not incorporate social values in the assessment (Lesslie and Maslen 1995). And yet there is recognition that inclusion of social and cultural criteria could improve the quality of wilderness assessment (Ananda and Herath 2002), and some research has actually mapped perceptions of wilderness conditions for integration with GIS (Kliskey and Kearsley 1993).

The challenge of integrating multiple ethnocentric definitions of wilderness into wilderness quality mapping has resulted in wilderness inventory methods that largely rely on physical landscape features to the exclusion of perceptual measures. The landscape values method reported herein suggests it may be possible to identify areas with perceived wilderness values without actually asking individuals about the specific location of wilderness. An indirect method of measuring wilderness quality that incorporates human perceptions can be highly advantageous where the wilderness concept has become bound up in political ideology, as in Alaska. If wilderness policy discourse focuses on the mix of publicly perceived landscape values that are known to correlate with wilderness quality and not the designation of wilderness per se, it may be possible to maintain or even expand de facto wilderness areas in an unfavorable political climate.

In practice, the moderate strength of the regression model indicates it may not be possible to derive a simple linear combination of landscape values that wholly describes a wilderness landscape. But the landscape values approach to mapping wilderness does appear to provide enough predictive power, and is sufficiently operational to warrant further research into its use with future GIS-based wilderness quality assessments. Future research will seek to determine how GIS-based methods that use remoteness and naturalness attributes compare to methods based on mapping perceived landscape values. **IJW**

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GREGORY BROWN is senior lecturer in the School of Natural and Built Environments, University of South Australia, Mawson Lakes Campus, Mawson Lakes, South Australia 5095. E-mail: greg.brown@unisa.edu.au.

LILIAN ALESSA is assistant professor, Department of Biological Sciences, University of Alaska, 3211 Providence Drive, Anchorage, AK 99508, USA. E-mail: lil@uaa.alaska.edu.